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UNITED STATES DEPARTMENT OF AGRICULTURE

DEPARTMENT BULLETIN No. 1475

Washington, D. C. February, 1927

PRODUCTION AND UTILIZATION OF FATS FATTY OILS, AND WAXES IN THE UNITED STATES

By

GEORGE S. JAMIESON, Bureau of Chemistry

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PRODUCTION AND UTILIZATION OF FATS, FATTY OILS, AND WAXES IN THE UNITED STATES [1]

By GEORGE S. JAMIESON, *Chemist, in charge Oil, Fat, and Wax Investigations Bureau of Chemistry*

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INTRODUCTION

The life and the progress of a nation depend in no small measure upon its supply of fats and fixed, or fatty, oils. Not only are these substances an essential part of our diet, but they play an important rôle in many industries as well. Oils and fats are used in the manufacture of soap, glycerine, paints, varnishes, lubricants, and waterproofings. Our requirements for them continually increase as the population grows and industries expand.

[1] This bulletin is a revision of and supersedes Department Bulletin 769.

Substances belonging to several distinct groups are termed oils. Mineral oils, which include the petroleum and shale oils, are known also as hydrocarbon oils because they are composed chiefly of mixtures of substances which are chemical combinations of carbon and hydrogen. Oils of another group obtained by the destructive distillation of coal tar consist chiefly of a mixture of hydrocarbons and phenols. The so-called carbolic acid is an example of this group.

Odoriferous oils, which are obtained by distillation with steam or by pressure from leaves, stems, flowers, seeds, roots, and bark of plants, and from the skins of citrus fruit, are known as volatile or essential oils. These are usually complex mixtures of substances known to the chemist as terpenes, aldehydes, ketones, alcohols, phenols, and esters (chemical combinations of acids with alcohols). Most of them are liquid, but some are semisolid or solid. The substances discussed in this bulletin are called fixed or fatty oils and fats to distinguish them from the volatile or essential oils.

There is no distinct chemical difference between a fat and a fatty oil. Each is composed chiefly of glycerides, substances formed by the combination of fatty acids with glycerine. Products which are liquid at ordinary temperatures are termed oils. Those which are solid at ordinary temperatures are commonly called fats. Some of the oils obtained from fruits and seeds are not liquid, but are either solid fats or butters, like cacao butter. On the other hand, lard, tallow, and other land-animal fats are more or less solid at ordinary temperatures. The fats or oils from fish, whales, and almost all other marine animals are liquid.

For convenience, the fats and oils considered in this bulletin may be divided into three general classes: Drying, semidrying, and nondrying. This classification is based upon the capacity for absorption of oxygen (both rate and quantity). These classes are not sharply defined, the oils of one class gradually merging into those of the next class. The oils which rapidly absorb oxygen and form solid films, such as linseed, China-wood or tung, perilla, and menhaden oils, are classed as drying oils. Oils of the semidrying class absorb oxygen less rapidly than the drying oils. This class includes cottonseed, corn, sesame, and mustard-seed oils. The nondrying oils absorb oxygen very slowly. To this class belong the land-animal fats and olive, castor, peanut, coconut, and palm oils.

In the following pages the more important edible vegetable oils are treated first in the order of their importance, irrespective of the class to which they belong. The less important edible and technical vegetable oils come next. The vegetable drying oils, with the exception of soy-bean and sunflower-seed oils, have been grouped together. Then follow the land-animal fats, fish and marine-animal oils, and the waxes.

GENERAL METHODS OF PRODUCTION

The profitable production and refining of fats and oils require an intimate knowledge of the raw materials and details of manufacture, which can be mastered only through experience, and also a knowledge of market conditions for both the raw materials and the finished products.

Vegetable oils are commonly expressed from the seeds or fruit containing them, either by hydraulic presses or by continuous work-

ing expellers. Nowadays, particularly in Europe, large quantities of oils are extracted by the use of volatile solvents, such as gasoline and benzene. Olives, peanuts, and sesame seed are pressed cold, producing what is known as virgin or cold-pressed oils. As a rule, cold-pressed oils need only to be filtered to make them suitable for edible purposes. Most oil seeds in the United States are heated and pressed hot, because it is possible to obtain more oil by hot than by cold pressing. In many instances cold pressing is followed by one and sometimes more hot pressings. The hot-pressed and solvent-extracted oils contain coloring and flavoring substances, which are removed by refining before the oil is used for food or even, in many cases, for technical purposes.

The residue from pressing, which contains 5 to 12 per cent of oil, depending upon the character of the product pressed and the equipment used, is called press or oil cake. When not poisonous, it is with few exceptions converted into feed for livestock. Inedible or poisonous press cakes are used for fertilizers. When ground the press cake is called a meal. The residue from the solvent extraction of an oil, known as extracted meal, contains less than 2 per cent and frequently not more than 1 per cent of oil. It may be used for the same purposes as press cake. If used for feed, however, all of the solvent must be removed.

Nearly all hot-pressed oils are refined before being used. The most common method is to treat the warm oil with a solution of caustic soda (sodium hydroxide), which neutralizes the free fatty acids to form soap and precipitates much of the coloring matter. After further agitation and heating to the proper degree the soap separates from the oil in small soft aggregates. This stage of refining is called the break. On standing, the soap settles to the bottom of the refining kettle to form the soap stock, which is used by soap makers. At some plants the soap stock is acidified with sulphuric acid to set free the fatty acids, which, with the neutral oil occluded in the soap stock, rise to the surface and are removed. This is sold as acidulated soap stock.

In the larger refineries it is customary to separate the fatty acids from the soap stock and after suitable treatment to distill them under diminished pressure. The distilled fatty acids are used by candle and soap makers. The residue in the still after distillation is known as pitch. The product obtained by the distillation of cotton-seed oil fatty acids, called cotton oil or stearin pitch, is employed, for one thing, in the manufacture of roof paint.

The term foots, sometimes used in place of "soap stock," is not to be confused with the term "olive oil foots," the name given to the low-grade olive oil extracted by solvents from the olive pomace or press cake. Olive oil foots is sometimes called sulphur olive oil, because it is largely extracted by carbon disulphide. The term foots is applied also to the settlings, which are allowed to separate in the settling tanks at crude oil mills before the oil is shipped to the refinery.

To obtain most animal fats or oils, the tissues in which they exist are cut in pieces and rendered or tried; that is, heated until the melted product separates. After the separated fat has been withdrawn, the cracklings, or cooked tissues, are usually pressed to

recover as much as possible of the fat. Instead of heating hog fat in steam-jacketed kettles, some lard makers cook it under pressure with live steam in closed tanks. This gives what is known in the trade as steam lard, in contradistinction to kettle-rendered lard.

Bleached, deodorized oils are desirable for making lard substitutes. The caustic soda refined oil is heated with fuller's earth, activated carbon, or a mixture of the two, depending upon the oil to be bleached, and filtered through filter presses. Then it is placed in a vacuum kettle and deodorized by superheated steam, which is blown through until the odor or flavor is removed.

During the last 15 or 20 years large quantities of oils have been converted into solid products by a process known as hydrogenation. In this hardening process specially prepared nickel powder is used to effect the combination of hydrogen gas and the liquid glycerides. The hydrogen unites with the olein of the oil, changing it into stearin, which is solid at ordinary temperatures. At the end of the process the nickel is removed by filtration while the oil is still hot. A substance which, like the nickel in this case, assists the combination of one substance with another, hydrogen and olein here, but does not itself unite with the final product, is called a catalyst. Great quantities of hydrogenated or hardened oils are used in the manufacture of lard substitutes, margarine, and soap. During hydrogenation whale and fish oils lose their fishy odor and taste. In some countries hydrogenated whale oil is used in making margarine.

Red oil, or commercial oleic acid, is obtained by chilling mixtures of fatty acids until the palmitic and stearic acids have crystallized. The solid acids are separated from the red oil by filtration and pressing. The composition of both the red oil and the solid acids depends upon the source of the mixed fatty acids. Some red oils are chiefly oleic acid with small quantities of dissolved palmitic and stearic acids; others contain notable quantities of linolic acid. With few exceptions the solid acids are sold as commercial stearic acid and are used in the manufacture of candles and soap. Red oil goes chiefly into textile soaps and sulphonated red oils (p. 18).

Greases, or inedible fats, obtained in meat-packing and rendering plants are graded and sold on the basis of color and percentage of fat present. Most of the grease produced and that recovered from tankage and garbage, after suitable treatment, are used in making soap or lubricants.

Vegetable waxes are widely distributed, but with few exceptions they occur only in very small quantities. Wax serves as a protective coating for the leaves, stems, and seeds of many plants. Unlike the oils or fats, waxes of either animal or vegetable origin are not composed of glycerides. They contain fatty acids in combination with what are known as higher alcohols. When separated in a pure condition these alcohols are white solids.

VEGETABLE OILS

COTTONSEED OIL

Cottonseed oil is obtained from the seeds of the cotton plant, which is cultivated throughout large areas of the southern United States. Although the composition of the cottonseed depends upon

the variety of the plant and the climatic conditions under which it is grown, the average oil content is about 20 per cent. The production of cottonseed oil in the United States exceeds that of any other single vegetable oil.

Preparation

As it comes from the gins, cottonseed is almost always heavily coated with short lint and mixed with broken bolls, stems, sand, nails, and other trash. Before it can be pressed it must be cleaned and delinted. To remove the trash, the seed is run through revolving screens, which separate the larger pieces of débris, over shaking screens and magnets and through cyclone cleaners, to remove sand, nails, and dust. The clean seed is then fed into the delinters, which consist of a series of fine-tooth circular saws set close together on a rapidly revolving shaft. At the back of each delinter a long cylindrical brush runs so close to the saws that it catches the cut fibers or linters and passes them to a reel on the back of the brush. The linters collect on the reel into a compact felt that looks like cotton batting. This is baled for use in the manufacture of mattresses, paper, guncotton, and artificial silk.

The seed, now nearly free from lint, is sent through the hullers and passed over shaking screens, which separate the kernels from the hulls. The hulls are passed through hullers and separators once or twice more until they are practically free from the oil-bearing kernels or meats. The separated meats or decorticated seeds are passed through a series of three or more heavy steel rolls and delivered above the press room.

In the United States it is customary to press cottonseed once only. When hydraulic presses are used the seed is always heated or cooked before being pressed. Cooking is a most important step in the expression of oil by the hot process. Experience and judgment are necessary for the maximum yield of oil of the best possible grade. A steam-jacketed cooker, equipped with a mechanical stirrer, which mixes the meats thoroughly and prevents uneven cooking, is used for the cooking. Near its top the cooker is fitted with a perforated steam pipe, through which steam may be admitted to moisten the meats should they become too dry. A subheater, placed just below the cooker, is often used to keep the cooked batch hot until the presses are ready for it.

Pressing

The steel box frame hydraulic press, operating under a pressure of from about 3,000 to 4,000 pounds per square inch, is the type most commonly used for the production of American cottonseed oil. It consists of a series of horizontal steel plates, approximately 14 inches wide by 34 inches long, set one above the other, about 5 inches apart when the press is wide open. These perforated or channeled plates are provided with close-fitting steel sides or frames, so that the whole machine is really a series of boxes without ends, piled one upon the other, the lowest resting on the hydraulic piston. Above the top frame a heavy iron plate is fastened to the hydraulic piston cylinder by four heavy vertical rods, which serve as guides for the sliding frames.

A measured quantity of the cooked meats is dropped upon a strip of press cloth in the cake former—a press with a steel block containing in its upper surface a shallow groove the size of a single press box. It is so constructed that after the meal has been placed upon the press cloth, and the two ends turned up over the charge, pressure can be applied, and the cake, now covered with cloth except on its two long sides, can be subjected to a preliminary squeezing to make it compact. Pressure is applied to the charge in the cake former for an instant and then released. A sheet of steel the width of the groove is slid beneath the cake, which is removed, cloth and all, from the cake former and placed in the lowest frame of the press.

One after the other, all the frames or boxes are thus charged until the press is filled. The compressed air is then turned on gradually and the piston or ram forces the frames upward, each against the one above it. The oil squeezed through the cloths flows over the sides of the press into the gallery around the bottom frame and out through the trough to the settling cistern or tank. So perfectly has every detail for the operation of these large presses been planned that they are often filled, pressed, and discharged in less than half an hour.

The expeller, a continuous press, which is rapidly gaining favor among American cottonseed crushers, has an interrupted screw revolving inside a slotted steel barrel. The crushed seed or meats enter through a hopper at one end of the barrel, are passed along toward the other end, and are finally discharged around a cone, which can be set in or out of the outlet to give any desired pressure. Expellers are used for making cold-pressed and hot-pressed oil. The term cold-pressed is not strictly applicable to oil made in this way, because the seeds or meats, as the case may be, are tempered or warmed to some extent in the temperer above the expeller and are also heated by the friction in the expeller, so that the oil and cake come out warm, sometimes actually hot. Although the crude oil thus obtained differs from that obtained by regular hot pressing, it becomes the same after it has been refined.

SETTLING

The crude oil, whether obtained by using the hydraulic press or the expeller, contains some fine meal. It is customary to allow the oil to stand in settling tanks so that this meal will settle. The clear oil is then withdrawn and sent to the refinery.

REFINING

The crude oil received at the refinery is either transferred to the storage tanks or placed directly in the weighing tanks. It next goes to the refining kettles, tall cylindrical tanks with conical bottoms, provided with steam heating coils that extend part way up the sides, and a mechanical agitator. After the weighed quantity of oil to be refined has been warmed, if necessary, to about 85° F. the agitator is started and the proper quantity of caustic soda solution for this particular lot of oil, as determined previously by the chemist, is added. The agitation and heating are continued until the brown particles of

soap formed by the action of the caustic soda with the free fatty acids clot together into spongy masses. At this stage the temperature of the oil is 110° to 120° F. The steam is shut off from the heating coils and the agitator is stopped. The oil is allowed to stand until the precipitated soap (soap stock) has settled and become firm. Then the clear oil is carefully withdrawn from the soap stock and run into a tank. If necessary, the oil is washed with warm water to remove the last of the soap. At this stage the oil is known as summer yellow.

Large quantities of the summer yellow oil are heated and agitated with from 2 to 6 per cent of fuller's earth for a short time and then filtered through filter presses, thus becoming bleached. The bleached oil is transferred to the high-vacuum deodorizer, where superheated steam from perforated pipes at the bottom of the tank is blown through until it is practically odorless and tasteless. The deodorization process further bleaches the oil.

WINTERING

When cooled to about the temperature of the household refrigerator, cottonseed oil deposits stearin. To prevent this separation, which makes the oil undesirable for use in the home, it is held in chilled rooms until the stearin has separated. The olein, or liquid portion, of the oil is removed from the solid stearin by pressing or by passing the mixture through centrifugal separators. This process is known as wintering. A properly wintered oil remains liquid when left in the refrigerator.

GRADES

The following well-defined grades for cottonseed oil have been established by the Interstate Cotton Seed Crushers' Association:[2]

CRUDE OIL

Choice crude cottonseed oil.—Choice crude cottonseed oil must be pressed from sound decorticated seed; must be sweet in flavor and odor, free from water and settlings, and must produce when refined as required by these rules, choice summer yellow oil at a loss in weight not exceeding 6 per cent.

Prime crude cottonseed oil.—Prime crude cottonseed oil must be pressed from sound decorticated seed, must be sweet in flavor and odor, free from water and settlings, and must produce when refined, as required by these rules, prime summer yellow oil, with a loss in weight not exceeding 9 per cent, provided that any oil that refines with a greater loss than 9 per cent, but still makes prime summer yellow oil, shall not be rejected, but shall be reduced in price by a corresponding per cent of the contract price of the oil.

Basis prime crude cottonseed oil.—Crude cottonseed oil shall not be tenderable on a basis prime crude contract, if when refined as required by these rules it refines to a color darker than 35 yellow and 16 red.

Off crude cottonseed oil.—Oil neither choice nor prime shall be called off oil. When off oil is sold by sample, any oil tendered shall equal sample, but if it should refine at a loss exceeding the loss of the sample by not over 5 per cent, but otherwise equal, it is still a good tender at a reduced price in proportion to the excess loss. The buyer shall have the right to reject any tank of oil outright if it tests beyond 5 per cent refining loss as compared with sale sample.

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[2] INTERSTATE COTTON SEED CRUSHERS' ASSOCIATION. RULES GOVERNING TRANSACTIONS BETWEEN MEMBERS OF THE INTERSTATE COTTON SEED CRUSHERS' ASSOCIATION. p. 7–10. [n. p.] 1925.

Cold-pressed oil.—Oil produced by cold presses or expeller process is tenderable on contracts for the four grades of oil defined above when such products will refine within the requirements of the above rules. Sellers are required to specify cold-pressed oil on invoices.

Extracted oil.—Cottonseed oil, crude or refined, produced by extraction processes instead of by pressing, shall not be tenderable on contracts unless the nature of the oil is declared at the time of sale.

REFINED OIL

Choice summer yellow cottonseed oil.—Choice summer yellow cottonseed oil must be sweet in flavor and odor, prime in color, clear and brilliant in appearance, and free from water and settlings, and shall contain not more than one-eighth of 1 per cent free fatty acid.

Prime summer yellow cottonseed oil.—Prime summer yellow cottonseed oil must be clear, sweet in flavor and odor, free from water and settlings, and of no deeper color than the two combined standard glasses of 35 yellow and 7.6 red on Lovibond's equivalent color scale, and shall not contain more than one-fourth of 1 per cent free fatty acid.

Prime winter yellow cottonseed oil.—Prime winter yellow cottonseed oil must be free from water and settlings, sweet in flavor and odor, and of prime summer yellow color as described above and must stand clear, brilliant and limpid for five hours when tested as provided in these rules, and shall not contain more than one-fourth of 1 per cent free fatty acid.

Good off summer yellow cottonseed oil.—Good off summer yellow cottonseed oil may be off in flavor and/or odor, but must be prime in color and free from water and settlings, and shall not contain more than one-fourth of 1 per cent of free fatty acid.

Off summer yellow cottonseed oil.—Off summer yellow cottonseed oil shall be free from water and settlings, off in flavor or odor, but of no deeper color than the combined standard glasses of 35 yellow and 12 red on Lovibond's color scale, and shall not contain more than one-half of 1 per cent of free fatty acid.

Reddish off summer yellow cottonseed oil.—Reddish off summer yellow cottonseed oil designated as such may be of inferior flavor and odor and of no deeper color than the two combined standard glasses of 35 yellow and 20 red on Lovibond's equivalent color scale, shall be free from water and settlings, and shall not contain more than three-fourths of 1 per cent of free fatty acid.

Bleachable prime summer yellow cottonseed oil.—Bleachable prime summer yellow cottonseed oil must be clear, sweet in flavor and odor, free from water and settlings, and when bleached as provided by these rules shall be of no deeper color than the two combined standard glasses 20 yellow and 2.5 red on Lovibond's equivalent color scale, and shall not contain more than one-fourth of 1 per cent of free fatty acid.

Prime summer white cottonseed oil.—Prime summer white cottonseed oil must be clear, free from water and settlings, sweet in flavor and odor, and shall be of no deeper color than the two combined standard glasses 20 yellow, 2.5 red on Lovibond's color scale, and shall not contain more than one-fourth of 1 per cent of free fatty acid.

Prime winter white cottonseed oil.—Prime winter white cottonseed oil must be brilliant, sweet in flavor and odor, free from water and settlings, and the color of the oil shall not be darker than the combined standard glasses of 20 yellow and 2.5 red on Lovibond's color scale, and must stand the cold test as prescribed in these rules, and shall not contain more than one-fourth of 1 per cent free fatty acid.

USES

Refined cottonseed oil is used chiefly in the manufacture of lard substitutes or shortenings and oleomargarine. It is also employed extensively as a salad and cooking oil. The inedible oil and soap stock obtained by refining the crude oil are used in making soap and soap powders. The press or oil cake is largely used as a feed for stock. Press cake of poor quality is used as a fertilizer. The stearin which separates when the refined cottonseed oil is wintered is used in making vegetable shortening.

COCONUT OIL

Coconut oil is prepared from the fruit of the coconut palm after it has been dried to form copra. Large quantities of coconut oil and of copra are imported annually into the United States from the tropical countries where the coconut palm grows.

Copra is prepared by breaking the coconut kernels and exposing the pieces to the sun or drying them in a kiln. The rotary drier, which gives a very uniform product, has been found to give the best results. When properly made and stored copra keeps well. Fresh coconut meat contains from 30 to 40 per cent of oil. Copra contains from 60 to 74 per cent, depending upon the method of manufacture.

Preparation

For many centuries the natives of the tropical countries where coconuts grow have boiled the kernels with water and skimmed off the oil as it floats to the surface. The modern method is to express the oil.

Because of its high oil content copra is generally pressed twice, neither pressing being made cold. Some mills press the copra once in an expeller press, regrind the cake, heat it, and press it a second time in a hydraulic press. The oils from the two pressings are combined and refined by methods about the same as those used for refining cottonseed oil (p. 6). Owing to the presence in coconut oil of glycerides of the lower fatty acids, which are more readily decomposed than those of the seed oils, greater care is necessary in refining to prevent an abnormally high loss from the conversion of neutral oil into soap.

Some coconut-oil refiners separate the portion of the oil which melts at a low temperature from that which is solid at higher temperatures. The low-melting portion is called coconut olein and the high-melting portion, coconut stearin.

Grades

The following well-defined grades of coconut oil have been established by the Interstate Cotton Seed Crushers' Association:[3]

CRUDE OIL

Choice crude coconut oil.—Choice crude coconut oil must be pressed and not extracted, and shall not contain more than 3 per cent free fatty acid calculated as oleic acid, shall be free from moisture and impurities, and shall have a color not greater than 12 yellow and 2 red.

Prime crude coconut oil.—Prime crude coconut oil shall be pressed and not extracted, and shall be free from moisture and impurities, and shall not contain more than 5 per cent of free fatty acid calculated as oleic acid, and shall have color no deeper than 30 yellow and 5 red on Lovibond's equivalent color scale; provided, that any oil that tests in excess of 5 per cent free fatty acid and less than 6 per cent free fatty acid, and has a color darker than 30 yellow, 5 red, and not darker than 30 yellow, 6 red, shall not be rejected, but shall be reduced in price one-half of 1 per cent of the contract price for each 1 per cent excess acid.

Off crude coconut oil.—Off crude coconut oil, neither choice nor prime, must be pressed and not extracted, and shall be called "off coconut oil." When "off

[3] Interstate Cotton Seed Crushers' Association. Op. cit. p. 12–14.

coconut oil" is sold by sample, if it should refine at a loss exceeding the loss of the sample by not over 5 per cent, but otherwise equal, it is still a good tender at a reduced price in proportion to the excess loss.

REFINED OIL

Refined coconut oil.—Refined coconut oil shall not contain free fatty acids in excess of one-tenth of 1 per cent, and shall be free from moisture and impurities, and shall not be darker than the combined standard glasses of 30 yellow and 3 red. If the oil tendered or delivered does not conform to these requirements, it may be rejected.

Refined deodorized coconut oil.—Refined deodorized coconut oil shall be free from moisture and impurities, sweet and neutral in flavor and odor, not in excess of one-tenth of 1 per cent free fatty acids, and shall not be darker than the combined standard glasses of 12 yellow and 2 red. If the oil tendered or delivered does not conform to these requirements, it may be rejected.

USES

One of the most important uses for refined coconut oil in the United States is in the manufacture of vegetable margarines, some of which are called nut margarine (p. 27).

Coconut olein is used as a cooking oil, and coconut stearin is used in making margarine, confectionery, and sweet fillings for cookies and wafers. Large quantities of coconut oil, as well as the soap stock from refining the edible oil, are used in soap making. The press cake from the oil mill is a valuable stock feed.

Large quantities of coconut shells are now used for the preparation of a special product known as activated charcoal.

PALM-KERNEL OIL

Palm-kernel oil, similar both chemically and physically to coconut oil, is obtained from the palm nut, the hard seed of the fruit of a palm (*Elæis guineensis* and subspecies) which grows wild in western Africa and is cultivated in some other tropical regions.

The Africans crack the nuts with hammers and send the kernels to the seaports for shipment to Europe or America. In the United States the kernels, which contain from 45 to 50 per cent of oil, are crushed and pressed in the same manner as copra (p. 9). In some European countries they are extracted with volatile solvents.

Palm-kernel oil can be used instead of coconut oil in making vegetable margarine and other food products as well as soap.

PALM OIL

Palm oil is obtained chiefly from the fleshy portion of the fruit of the palm (*Elæis guineensis* and subspecies), the oil content of which ranges from 35 to 60 per cent, depending upon the species of the tree and the place where it grows.

Most of this oil is still made by the crude and primitive process that has been in use for centuries. Attempts to introduce modern methods and equipment into the African palm regions have not been successful. However, improved methods will soon go into effect in Java, where large plantings are beginning to bear fruit. As the hard fruit must be softened before the kernels can be removed, the Africans put the freshly picked fruits in leaf-lined holes in the ground, moisten them, cover them with leaves, and let them stand for two

weeks or longer. The fleshy parts, softened by fermentation, are then placed in a hole lined with stones and beaten with long stout poles. The crushed fruit is transferred to another hole, the sides of which are lined with a mixture of palm oil and wood ashes, and left for about a week. Some of the oil drains from the pulp to the lower part of the hole. The kernels are removed, and a further yield of oil is obtained by boiling the pulp with water. Another method is to place the fermented pulp in a bag and squeeze out the oil. These crude methods of extraction account in great measure for the large quantity of free fatty acids present in the palm oil received in this country.

The consistence of commercial palm oil varies from that of a soft butter to that of tallow. Its color ranges from orange yellow to dark red. In trade the following grades of palm oil are recognized: Soft oils—Lagos, Calabar, Opobo, Bonny; hard oils—Congo, Niger, Oil River, Liberia, Gold Coast; mixed oils—Gold Coast and Niger. The hard oils contain very large quantities of free fatty acids.

Palm oil is employed principally in the soap-making and tin-plate industries.

COHUNE OIL

Cohune oil is obtained from the nuts of a palm (*Attalea cohune*) growing from the southern side of the Yucatan Peninsula in Mexico, through the coast region of British Honduras, Guatemala, and Honduras. Like most varieties of palm, cohunes are found only in the rich tropical lowlands which are well drained. The cohune fruits are on an average about the size of a hen's egg. The nut, which frequently contains two kernels, is inclosed in a thick fibrous husk.

The expansion of the cohune-oil industry has been retarded by the difficulty of gathering and cracking the nuts. Few of the many machines devised for this purpose have proved satisfactory. About 10 tons of the nuts are required to give 1 ton of kernels.

The kernels contain 40 per cent or more of an oil which resembles coconut oil and can be used for the same purposes (p. 10). The oil of the husk of the cohune nut differs from that of the kernels. It constitutes about 10 per cent of the husk and can be extracted with volatile solvents. Cohune shells can be used for fuel or they can be converted into a special charcoal (p. 10), preferably in retorts which permit the recovery of the volatile products, such as methanol (wood alcohol) and acetic acid.

COQUITO OIL

Small shipments of coquito nuts from a palm which grows on the west coast of Mexico are occasionally received in the United States. The shells of coquito nuts are thinner than those of the cohune and contain only one kernel. It is reported that by boiling the coquito nuts for about five hours in water the shells can be readily cracked. The oil expressed from the kernels, which is similar to cohune oil, is used for the same purposes as coconut oil (p. 10).

BABASSU OIL

Babassu oil is obtained from the kernels of the nuts borne on a palm (*Orbiginia speciosa*) closely related to the cohune and growing abundantly in some parts of Brazil. Twice a year this palm bears

three or four large bunches of fruit. Some trees yield a ton of fruit, which contains about 270 pounds of kernels. Like the cohune, the nuts have extremely thick and hard shells. It is said that the dried kernels contain from 65 to 68 per cent of oil, which is expressed in the same way as coconut oil (p. 9). The oil, being similar to coconut oil, is used for the same purposes.

CORN OIL

Corn oil is obtained from the small germ portion of the common Indian corn or maize. The United States is the largest producer of corn oil, but Canada, Argentina, and South Africa are producing it in increasingly large quantities.

The germ of corn is about half oil, but on the basis of the whole kernel the oil content is only from 3 to 6.5 per cent. Were it not for the fact that in the preparation of hominy, cornstarch, and other corn products the germ is almost completely separated from the rest of the kernel, corn oil doubtless would be a mere curiosity instead of an important commercial product. Corn may be degerminated by the dry process, or by the wet process.

The wet process, employed in starch and glucose plants, is as follows: The cleaned corn is steeped from 30 to 40 hours in water containing about 0.2 per cent of sulphurous acid, removed from the water, and passed through an attrition mill of a special type. The shredded corn is mixed with a large quantity of water in floating vats, and the mixture is slowly agitated in such a manner as to cause most of the germs to float and pass over the lower end of the vat. The germs, together with much starchy water, are passed through reels with perforated sides and washed to remove the adhering starch. The washed germs are passed through moisture expellers and then through steam-heated rotary driers, which reduce the moisture content to about 5 per cent. The dried germs are passed through a set of flaking rolls, which break the oil cells but do not grind the material into flour. The general practice is to extract the oil with expellers, although hydraulic presses can be used.

The dry process is as follows: The cleaned corn is agitated in a suitable container and then treated with sprays of water or steam until it has a moisture content of about 20 per cent, after which it is passed through the degerminating machine. The germ thus separated contains some bran and meal, the quantity depending on the care practiced in operating the machine. The germ material is dried and passed through hominy reels, which remove more of the bran and meal. Then the germs are passed through the flaking rolls and the oil is expressed with expellers.

As the dry-process germs are mixed with meal, the yield of oil is only about 0.5 pound per bushel of corn. By the wet process it is about 1.5 pounds. As would be expected, however, the oil obtained from the dry-process germs is of much better quality than that from germs obtained by the wet process.

Most of the corn oil is now refined in a manner somewhat similar to that employed for cottonseed oil (p. 6).

Corn oil is used for edible purposes, in the manufacture of some soaps, and, along with linseed oil, in paste paints to prevent hardening in the containers.

OLIVE OIL

Olive trees are cultivated in the countries bordering on the Mediterranean and in South Africa, Australia, the United States, Mexico, and Peru. The oil content of olives depends largely upon the variety and upon soil and climatic conditions. Olives cultivated for oil contain from 30 to 60 per cent. California olives contain from 12 to about 30 per cent. Climatic conditions affect the quality of the oil so greatly that the olives in a given region may one year produce a very fine oil and the next yield one of poor quality.

California produces about 200,000 gallons of olive oil a year. The United States annually imports from 3,000,000 to 6,000,000 gallons from Italy, Spain, France, Greece, and Northern Africa. Italy and Spain furnish the larger part.

Preparation

The methods and equipment employed, both in the extraction and subsequent treatment of the oil, vary in different countries. In Europe much oil is still made in a very primitive manner, but in recent years up-to-date plants have been gradually replacing the older mills in the large olive-crushing centers in France, Italy, and Spain. In some of these plants centrifugals are employed for the separation of the oil from the expressed juice.

For the production of the finest oil, the olives should be gathered just before complete maturity. As most of the olives in California are grown for pickling, the cull olives—those that are undersize, bruised, or overripe—are chiefly employed in making olive oil. These are washed, freed from leaves and other foreign substances, and crushed, in many of the mills with fluted rollers so adjusted that the pits are not broken.

First pressing

The crushed olives are placed in heavy coarsely woven cloths, which are folded to envelop completely each layer or cake of crushed fruit. These cakes are piled on top of one another, with wooden slats between, until the capacity of the press has been reached. Hydraulic presses adapted to the pressing of olives are commonly employed, but presses operated by screws or gears are used in some plants. During the first pressing the pressure is gradually increased to 500 pounds per square inch.

Clarification

The mixture of oil and juice from the presses is transferred to a continuous oil washer, and the oil is rapidly separated from the juice and larger particles of pulp. The washed oil, rising to the top of the washing tank, is drawn off into settling tanks for separating the water and any pulp not removed by the washing. By allowing the oil to stand a month in the first tank and then transferring it to a second and later to a third settling tank a perfectly clear oil may be obtained. This method of clarifying takes three months or longer. In some mills the oil is filtered through filter paper or cotton filters until perfectly clear.

SECOND AND THIRD PRESSING

The press cake is ground and a second pressing is made at a pressure much higher than that used in the first pressing. Most of the oil is obtained in the second pressing. It is of good quality and is usually combined with oil of the first pressing. The press cake with the pits is ground again with a little hot water and pressed at a still higher pressure. Oil obtained by such a third pressing is classed as inferior to strictly cold-pressed oil.

EXTRACTION

In Europe the oil remaining in the press cakes is extracted with volatile solvents, such as carbon disulphide, benzene, gasoline, and trichlorethylene. The extracted oil, from which the solvent has been removed, is known as sulphur olive oil or extracted olive oil, and is imported into the United States as olive oil foots.

USES

Olive oil is highly esteemed as a salad oil, and it is also widely used medicinally. Olive oil foots are imported into the United States principally for making soap. The press cake is utilized chiefly for boiler fuel and for supplying humus to orchards.

PEANUT OIL

The peanut is an important crop in the United States as well as in Africa, China, India, and Japan. Farmers' Bulletin 1127[4] describes the varieties grown in this country. The Spanish type, which can be cultivated under a wider range of soil and climatic conditions than the other varieties, is the one usually grown here for the production of oil.

The quantity of peanuts crushed for oil in the United States varies greatly from year to year with the market demand for the nuts for other purposes. When the price of peanuts is so high as to prohibit their general use for pressing, nuts discarded by the shelling plants are the principal sources of the oil.

PREPARATION

Department of Agriculture Bulletin 1401[5] discusses in detail the preparation of peanut oil. High-grade oil is made only from sound, well-matured peanuts and by employing only careful methods of manufacture and storage. Large quantities of low-grade nuts which accumulate at the cleaning and shelling plants are also pressed. Some of the oil thus obtained is refined for edible purposes. The lowest-grade oil goes to the soap maker. This practice of utilizing discarded peanuts for oil is a distinct advantage to the industry, unless the oil is sold for purposes to which it is not adapted.

Cottonseed-oil mills are used largely in the manufacture of peanut oil for the reason that these mills are frequently near, if not in, the

[4] BEATTIE, W. R. PEANUT GROWING FOR PROFIT. U. S. Dept. Agr. Farmers' Bul. 1127, 33 p., illus. 1920

[5] CLAY, H. J., and WILLIAMS, P. M. MARKETING PEANUTS. U. S. Dept. Agr. Bul. 1401, 99 p., illus. 1926.

peanut-growing sections and only a small additional investment is required for the equipment needed for cleaning and shelling the nuts. The utilization of cottonseed-oil mills saves the expense of separate buildings and equipment.

COLD PRESSING

To obtain a very pale cold-pressed oil, the kind preferred by Europeans, the red skins must be removed before pressing. In the United States it is customary to cold press the shelled nuts without separating the red skins. An excellent oil, with a color somewhat deeper than that of the oil expressed from decorticated kernels, is thus obtained.

To express the oil by the hydraulic press, the kernels must be passed through rolls to crush the oil cells as thoroughly as possible, but leaving the product in a suitable condition for the extraction of the oil. When the oil is to be expressed by the continuous working oil expeller, the kernels are frequently first crushed to a coarse meal. If the kernels have not been crushed before being passed through the expeller, the cake is ground and pressed again for a further recovery of the oil. In Europe, where the hydraulic press is commonly employed, the cake, after cold pressing, is ground, moistened, cooked, and hot pressed.

HOT PRESSING

Most of the peanut oil produced in this country is obtained by hot pressing. The crushed nuts are heated or "cooked" in a cottonseed or other cooker before expressing the oil.

Formerly, unshelled nuts were crushed and pressed, but this practice yielded less oil because of the absorbent character of the shells.

REFINING

The hot-pressed oil is refined by the caustic-soda process, bleached, and deodorized in a manner similar to the refining of cottonseed oil (p. 6). The refining of peanut oil requires experience, which can be obtained only at a refinery, partly because different shipments of oil may vary in character, so that the refining procedure must be modified to obtain satisfactory results.

GRADES

The following well-defined grades of peanut oil have been established by the Interstate Cotton Seed Crushers' Association:[6]

CRUDE OIL

Choice crude peanut oil.—Choice crude peanut oil must be pressed and not extracted, from sound peanuts, must be sweet in flavor and odor, free from water and settlings, and shall produce, when refined as required by these rules, choice yellow peanut oil with a loss in weight not exceeding 3 per cent.

Prime crude peanut oil.—Prime crude peanut oil must be pressed and not extracted, from sound peanuts, must be sweet in flavor and odor, free from water and settlings, and must produce prime yellow peanut oil when refined

[6] INTERSTATE COTTON SEED CRUSHERS' ASSOCIATION. RULES GOVERNING TRANSACTIONS BETWEEN MEMBERS OF THE INTERSTATE COTTON SEED CRUSHERS' ASSOCIATION. p. 10–12. [n. p.] 1925.

as required by these rules, with a loss in weight not exceeding 5 per cent; provided, that any oil that refines with a greater loss than 5 per cent, but still makes prime yellow peanut oil, shall not be rejected, but shall be reduced in price by a corresponding per cent in the contract price of the oil.

Basis prime crude peanut oil.—Crude peanut oil shall not be tenderable on a basis prime crude contract if, when refined as required by these rules, it refines to a color darker than 35 yellow and 10 red.

Off crude peanut oil.—Off crude peanut oil, neither choice nor prime, shall be called "off" oil. When "off" oil is sold by sample, the oil tendered shall equal sample, but if it shall refine at a loss exceeding the loss of the sample by not over 3 per cent, but otherwise equal it, it is still a good tender at a reduced price in proportion to the excess loss. The buyer shall have the right to reject the oil outright if it tests beyond 3 per cent refining loss as compared with the sale sample.

REFINED OIL

Choice peanut oil.—Choice peanut oil must be sweet in flavor and odor, prime in color, clear and brilliant in appearance, and free from water and settlings, and shall not contain more than one-tenth of 1 per cent of free fatty acid.

Prime yellow peanut oil.—Prime yellow peanut oil must be clear, sweet in flavor and odor, free from water and settlings, and of no deeper color than the two combined standard glasses 35 yellow and 5 red on Lovibond's equivalent color scale, and shall contain not more than one-fourth of 1 per cent of free fatty acid. The color examination shall be made as prescribed in the official methods of this association.

Good off yellow peanut oil.—Good off yellow peanut oil may be off in flavor and odor, but must be prime in color and free from water and settlings, and shall not contain more than one-fourth of 1 per cent free fatty acid.

USES

Peanut oil, one of the most important of the world's food oils, is used as a salad and cooking oil and in the manufacture of margarine and some vegetable shortenings. It is also used in the manufacture of soap. The cold-pressed oil, commonly called virgin peanut oil, has a mild, nutty flavor. Both the cold-pressed oil and the hot-pressed oil, after it has been refined, can be used for all culinary purposes except in making pie crust, for which a semisolid fat, like lard or vegetable shortening, is preferred.

The meal is rich in protein and is a good stock feed. A portion of the shells is frequently ground with the oil cake to give bulk to the meal. Shells add little to the food value of the mixture, however. At some mills the shells not ground with the oil cake are burned under the boilers or sold as bedding for livestock.

The oil expressed from the germs and red skins is sent to the soap maker.

SOY-BEAN OIL

Soy-bean oil is obtained from the seeds of a plant indigenous to China, Manchuria, and Japan. Soy beans are now cultivated in most of the temperate or subtropical regions of the world, including the United States. Although more than 500 known varieties have been grown on Government-testing farms in this country, at present only about a dozen varieties are grown in commercial quantities. The Mammoth (yellow), the standard late variety, is much more extensively cultivated than any of the others. When the beans are to be utilized for oil care should be taken to select the variety that will yield the maximum quantity per acre. The oil content of soy beans varies greatly in different localities, ranging from about 13 to

23 per cent. Unless soy beans which contain 17 per cent or more of oil can be grown, it is not practical to cultivate them for the expression of oil.

Preparation

In Europe an increasingly large quantity of soy-bean oil is being obtained by extracting the crushed seeds with volatile solvents, although most of the oil is still expressed. At times large quantities of soy beans, both domestic and imported, have been crushed for oil in the United States. Cottonseed-oil mills can handle soy beans with little or no change in their equipment. Some oil also is made in mills equipped with expellers.

Grades

The following grades of soy-bean oil have been established by the Interstate Cotton Seed Crushers' Association.[7]

Prime crude soy-bean oil.—Prime crude soy-bean oil shall be pressed and not extracted from soy beans, free from water and impurities, and when refined by the association's official methods, shall produce an oil of no deeper color than the two combined standard glasses of 35 yellow and 9 red, with a loss not exceeding 5 per cent; provided that any oil that refines with a greater loss than 5 per cent, but still makes prime refined oil with a color reading not exceeding 35 yellow and 9 red, shall not be rejected, but shall be reduced in price by a corresponding per cent of the contract price of the oil.

Crude soy-bean oil.—Crude soy-bean oil sold basis 7 per cent refining loss shall be pressed and not extracted, from soy-beans, and shall be free from water and impurities, and when refined as prescribed in the official methods of this association, shall produce an oil of no deeper color than the two combined standard glasses 35 yellow and 11 red, with a loss not exceeding 7 per cent; provided, that any oil that refines with a greater loss than 7 per cent, but still makes refined oil with a color reading not exceeding 35 yellow and 11 red. shall not be rejected, but shall be reduced in price by a corresponding per cent of the contract price of the oil.

Uses

Belonging to the group of drying oils, soy-bean oil stands midway in its properties between linseed oil and the semidrying cottonseed oil. Consequently it can be used as a substitute for either of these two oils, especially in soap making. In the manufacture of soft soap, soy-bean oil serves as an almost complete substitute for linseed oil. In the manufacture of hard soap it can but partially replace cottonseed oil unless it is hydrogenated. It is extensively used as a substitute for part of the linseed oil in certain kinds of paint, as well as in the manufacture of linoleum. It is perfectly wholesome and in China and other Asiatic countries forms the staple food oil of large classes of people. When properly refined the oil loses its characteristic beany flavor and can be used in the manufacture of lard substitutes, in margarine, and even as a salad oil.

CASTOR OIL

Castor oil is obtained from the seeds of the castor-oil plant (*Ricinus communis*), found in most tropical and subtropical regions, where it grows wild and is also cultivated. This plant varies greatly

[7] Interstate Cotton Seed Crushers' Association. Op. cit. p. 13.

in size, in the color of its stems, and in the size and color markings of its seed. The oil content of the seeds ranges from 35 to 55 per cent, the average being about 45 per cent.

The seed and oil of commerce come chiefly from India, China, the West Indies, and South America. India produces by far the largest quantity. During the nineteenth century large quantities of castor beans were produced in the United States, chiefly in Oklahoma, Kansas, Missouri, and Illinois. In 1900, however, production fell off until 1918, when, in response to the demand for aircraft lubricants, a crop estimated at 5,750 tons was produced in the Southern States.

Preparation

The castor beans, freed from trash and stones, are decorticated in machines made for this purpose and are cold pressed, usually in hydraulic presses. The No. 1 oil is pressed from sound seeds only. The resulting press cake is ground, heated with steam, and pressed hot to give the No. 3 oil. A bushel of castor beans (46 pounds) yields about 15 pounds of No. 1 and about 4 pounds of No. 3 castor oil. In some mills, after either the first or second pressing, the residual oil in the press cake is extracted with a volatile solvent, such as benzine or gasoline.

Expellers, sometimes used to express the castor oil, press at the rate of 17 or 18 bushels of castor beans per hour. Expellers used for this purpose should have three worm flights on the pressing screw or shaft. The expeller with two worm flights has been found unsatisfactory.

Before the No. 1 oil is placed on the market it is customary to heat it in a vacuum to remove the moisture and then agitate it with 2 to 4 per cent of fuller's earth, along with 0.2 to 1 per cent of a bleaching carbon. The treatment of the oil is finished when the bleaching agents are removed by filtration. No bleaching has been found effective for the No. 3 oil. This is attributed in part to the fact that with the present practice the color is fixed by overheating. Highly colored castor oil can be refined and bleached only when it has received the same care as is given to the preparation of other vegetable oils to be bleached.

Grades

The trade determines the quality of the oil by its color, clearness, and acidity. No. 1, a cold-pressed oil, is low in acidity, brilliantly clear, and nearly colorless. No. 3 varies in color from brownish yellow to dark brown or dark green. The trade does not recognize any grade as No. 2.

Uses

The No. 1 oil is used for medicinal purposes and the No. 3 for technical purposes. The oil which has been extracted with a volatile solvent is sold for technical purposes after the removal of the solvent. As the press cake or extracted castor-oil meal is poisonous, it is used only as a fertilizer.

A large quantity of castor oil is converted into the sulphonated castor oil of commerce, known for many years as Turkey red oil because of its use in dyeing cotton fabrics with alizarine. The pro-

duction of sulphonated oil requires both skill and experience. Sulphonated castor oil is used in the dyeing of fabrics to give clearer and brighter colors, and as an aid in the finishing of cotton, linen, silk, and leather. Castor oil is important also as a lubricant and enters into the manufacture of some soaps and imitation leathers.

SESAME OIL

Sesame oil, also known as gingili, teel, and benne, is made from the seeds of an herbaceous annual, 2 to 4 feet high, of the Sesamum genus. Sesame plants have been cultivated in India and elsewhere in the East from time immemorial, and are now grown in most countries with a tropical or subtropical climate, China and India being the largest producers. In the United States sesame seed has not been grown for oil because it is necessary to pick by hand the seeds as they ripen. Otherwise the pods quickly explode and scatter the small seeds over the ground.

Sesame seeds range in color from almost white to black. The so-called white seeds yield the finest oil and the black seeds the poorest. The importations of both seed and oil into the United States have increased during the last few years.

The oil may be expressed from the seed by hydraulic presses or expellers. As the seed contains more than 50 per cent of oil, however, special experience is necessary to satisfactorily extract the oil and produce a press cake of low oil content.

Sesame oil is one of the important food oils. Both the cold-drawn and the refined hot-pressed oil are used in salads, in cookery, and in the manufacture of margarine. The lower grades are employed in soap making. The press cake is an excellent cattle food.

SUNFLOWER-SEED OIL

Sunflower-seed oil is obtained from the seeds of the large cultivated sunflower, which usually contain from 20 to 25 per cent of oil. Russia and China are the chief producers of this oil.

The sunflower seed produced in the United States, which for some time has amounted to several million pounds per year, is used chiefly in the preparation of poultry feeds. The important sunflower-seed producing areas are southeastern Missouri, southern Illinois, and the San Joaquin Valley in California. Only small quantities of the oil have been expressed in this country.

In Russia the cold-pressed oil is used for edible purposes and the hot-pressed oil is employed chiefly in making soap and varnish. The oil is utilized to some extent in the United States for food and technical purposes.

FIXED OIL OF MUSTARD SEED

Mustard-seed oils are obtained from several varieties of mustard, the seeds of which vary in color from nearly white to dark brown and usually contain from 25 to 35 per cent of fixed oil. Mustard seed is grown in Asia, Europe, and other countries.

In the grain elevators of the Northwest hundreds of tons of wild oil-bearing seeds, chiefly brown mustard and charlock, are separated. The seeds are pressed and the oil is sold to soap makers. The mustard-seed oils, which resemble rapeseed oil in many respects,

are used chiefly for technical purposes. In India and some other countries mustard-seed oil is used for edible purposes.

In the United States and Europe large quantities of the oil are obtained as a by-product in the manufacture of mustard flour and prepared mustards.

RAPESEED (COLZA) OIL

Rapeseed oil is obtained from the seeds of several varieties of the rape plant growing in India, Japan, and many European countries. The oil content of the seed ranges from 30 to 45 per cent.

Rapeseed oil is obtained both by expression and extraction with volatile solvents. It can be refined with sulphuric acid or with caustic soda in the same manner as linseed oil (p. 23). To increase its viscosity, air is frequently blown through the heated oil.

The cold-pressed oil is used for edible purposes in India and also in some European countries. The hot-pressed and solvent-extracted oil serves various technical purposes. The chief use of the oil, both here and abroad, is as a lubricant, particularly after it has been blown (p. 23). Some is used in soap making and for quenching or tempering steel plates. If free from mustard seed, the press cake or extracted meal is used as a cattle food in Europe. Otherwise it is used as a fertilizer.

CACAO BUTTER

Theobroma cacao plants, from which chocolate, cocoa, and cacao butter are obtained, grow in the tropical parts of South America, the West Indies, Africa, India, and other regions. Cacao beans, as the seeds of these plants are called, contain from 50 to 57 per cent of oil.

Cacao butter is usually a by-product from the manufacture of beverage cocoa, which is made by pressing decorticated roasted and crushed cacao beans. The press cake when ground and bolted constitutes cocoa; the expressed fat is cacao butter. Cacao butter can also be made by pressing ground unroasted beans. Some cacao butter is obtained by extracting the press cake or cocoa with a volatile solvent. When freshly extracted, cacao butter has a pale yellowish color, which becomes white after the product has stood for a few days.

Although the chief use of cacao butter is in the manufacture of confectionery, it is also an important ingredient of several pharmaceutical preparations.

SHEA-NUT OIL OR BUTTER

Shea-nut oil or butter, also called bambuk butter, karite oil, and Galam butter, is a semisolid oil obtained from the nut of a tree belonging to the Sapotaceæ, which grows abundantly on the west coast of Africa in the English and French Sudan. In size and shape the nuts resemble an ordinary plum. The oil content of the kernels ranges from 40 to 55 per cent.

In tropical Africa the natives extract the oil from the crushed nuts with boiling water. Comparatively little is extracted for export. Practically all that is used in the United States is obtained from imported nuts. In Africa the oil is used for edible purposes. That expressed in the United States goes to the soap makers.

ALMOND OIL

Most almond oil is obtained from bitter almonds, although some is expressed from sweet almonds. No difference between the oils from the two kinds of almond can be detected by chemical means. The fixed oil of almonds is placed on the market under the name of sweet almond oil, thus distinguishing the fatty oil from the essential or volatile oil of the bitter almond, which is obtained from the bitter-almond cake. Prior to 1914 the imports of this oil into the United States frequently exceeded 100,000 pounds, but in recent years they have fallen to about 2,000 or 3,000 pounds, owing in part to the increased production of the oil in California.

Almond oil belongs to the nondrying class and has good keeping qualities. It is used chiefly in the manufacture of pharmaceutical preparations.

APRICOT-KERNEL OIL

Apricot-kernel oil is obtained by expressing the kernels from apricot pits. When first expressed this oil is nearly colorless, but on standing it gradually becomes yellow. All the color, however, can readily be removed by bleaching. In most respects apricot-kernel oil is similar to almond oil.

Apricot kernels contain from 40 to 45 per cent of oil. At one time large quantities of the pits from the dried-fruit industry of California were sent abroad, where the oil from the kernels was expressed and frequently shipped back to the United States. In recent years, however, the oil has been made in California.

Apricot-kernel oil is used as a salad oil and for pharmaceutical preparations.

GRAPE-SEED AND RAISIN-SEED OILS

Grape-seed oil is obtained from the seeds which are a by-product of the grape juice and wine industries. Raisin-seed oil is obtained from the seeds which are a by-product of the seeded-raisin industry. Grape-seed oil is made chiefly in Europe; raisin-seed oil is made in California.

Raisin seeds contain only about 14 per cent of oil. These seeds are treated with hot water to free them from the pulp, preferably decorticated, and then pressed. In Europe grape seeds are extracted by volatile solvents. Depending upon the variety of grape, the yield of oil ranges from 12 to 20 per cent.

Some grape-seed oil compares favorably with second-quality olive oil and is used for edible purposes. Large quantities of raisin seeds are now ground for feed. The expressed oil from raisin seed is used in the manufacture of soap. Like soy-bean and sunflower-seed oils, grape-seed and raisin-seed oils have drying properties. In Spain the oil, alone or with linseed oil, is employed in making paint.

CHINESE VEGETABLE TALLOW

Chinese vegetable tallow is the hard fat which coats the three oval seeds contained in the fruit of the Chinese tallow tree (*Stillingia sebifera*). China produces up to 10,000 tons of this fat a year. Much of it is sent to Europe and some is imported into the United States.

The tallow is obtained by steaming the seeds in perforated cylinders or by scraping them with special equipment. The seeds when crushed and expressed give an oil which is entirely different in character from the tallow. Sometimes the oil and tallow are expressed together.

Chinese vegetable tallow is used chiefly in the candle and soap industries.

JAPAN WAX OR TALLOW

Japan wax or tallow, which is not a wax but a vegetable fat, is obtained from sumac berries in China, India, and Japan. It is a by-product of the lacquer industry and is extracted in quantity only in China and India. Most of it is exported to Europe, but as much as 1,500,000 pounds has been imported into the United States in some years.

The sumac berries yield 15 to 25 per cent of a coarse, greenish, tallowlike fat. This substance is refined by remelting and filtering through cloth bags, which allow the melted fat to drop into cold water. The thin flakes are bleached by exposure to the sun after frequent turning and sprinkling with water. Finally, the tallow is melted and cast into slabs.

It is used largely in manufacturing polishes. Buyers state that the commercial product is frequently adulterated with various oils, especially hazelnut oil, and at times with as much as 30 per cent of water. It has the property of readily forming emulsions.

BAYBERRY TALLOW (MYRTLE WAX)

Bayberry tallow coats the outside of the berries of certain species of Myrica growing in North America, South America, and South Africa. The berries are boiled in water to obtain the tallow. The fat may be removed by skimming as it rises to the surface or it may be removed after it has solidified. The crude product is remelted in clean water to further purify it. Like Japan wax, it is a true fat and not a wax. This fat constitutes from 20 to 25 per cent of the materials used to make bayberry Christmas candles.

LINSEED OIL

Linseed oil is extracted from flaxseed, which is grown most extensively in Argentina, Canada, India, the United States, and Russia. Flaxseed contains from 32 to 42 per cent of oil, the fully matured seeds containing the most. Large quantities of the cold-pressed oil are made in Russia, Hungary, Germany, and India. The United States produces and uses more hot-pressed linseed oil than it does of all other purely technical oils combined.

Preparation

Most of the linseed oil made in the United States is expressed by means of open-plate hydraulic presses, although some is made in expeller mills. Abroad the oil is obtained both by expression and by extraction with volatile solvents. If a high-grade oil is to be made, the weed seeds must first be separated from the flaxseed. The average American yield is about 16 pounds of oil and 36 pounds of cake

per bushel of seed. The press cake usually contains 6 to 8 per cent of oil.

The hot-pressed oil contains some mucilaginous matter extracted from the seed, which must be removed from oil designed for certain technical purposes. When the oil is stored for a long time, the mucilaginous substances separate and gradually settle. A more rapid method, which has been in use for many years, consists in treating the oil with 1 or 2 per cent of sulphuric acid. This chars the impurities and causes them to separate from the oil. As linseed oil is easily damaged by using too highly concentrated acid, this method requires care and experience. Increasingly large quantities of the oil are being refined by the caustic-soda process in a manner similar to that employed for treating crude cottonseed oil (p. 6). This yields a product of great purity.

Linseed oil can be bleached by exposure to the sun, by treatment with benzoyl peroxide, dichromates, hydrochloric acid, ozonized air, and fuller's earth, and by blowing air through the heated oil. Refining by the sulphuric-acid and caustic-soda methods also removes a large part of the coloring matter present in the crude oil.

Boiled linseed oil is now generally prepared by heating the oil in steam-heated kettles with organic or inorganic compounds of lead, manganese, or cobalt, known as driers. The cost of producing this boiled oil is smaller than that of boiling over a direct fire, as was formerly done. To produce the light-colored oils air is passed through the heated oil. Boiled oil is sold as double-boiled, single-boiled, pale-boiled, extra pale, and bleached-boiled oil, and by various other trade names indicating differences in color, consistency, and drying properties.

Blown linseed oil is prepared by passing air through the heated oil until the desired viscosity is reached. In this process it is important to keep the oil at about 250° F., as a higher temperature impairs the color. Driers like cobalt linoleate should be added to the oil after it has cooled below 150° F. Blown oil of a light color is necessary for use in making special paints, varnishes, and enamels.

Stand linseed oil is made by heating thoroughly settled or refined oil in varnish kettles to about 550° F. and keeping it at this temperature until the desired viscosity is obtained. Aluminum kettles give the lightest-colored product.

Uses

In Russia, Hungary, Germany, and India large quantities of cold-pressed linseed oil are used for edible purposes. Hot-pressed oil is employed for technical purposes only, chiefly in the manufacture of paints, varnishes, enamels, linoleums, printing ink, and soft soap. Stand linseed oil is used in the manufacture of air-drying and baking enamels, and also as a lithographic oil for copper-plate printing.

CHINA-WOOD OR TUNG OIL

China-wood or tung oil is obtained from two species of Aleurites, a small genus belonging to the Spurge family. About 90 per cent of the oil produced in China comes from the seeds or nuts of the *Aleurites fordii*, which, being more hardy than the other species

(*Aleurites montana*), is much more widely distributed and grows in central and western China. *A. montana* is found in southeastern China from Fukien southward to Tonkin. In China *A. fordii* is known as the tung-oil tree, and *A. montana* as the wood-oil tree. The trade makes no distinction between the oils from these species, however, and the oil exported is frequently a mixture of the two. As the two oils are practically identical in composition and properties, nothing would be gained by keeping each by itself.

The use of tung oil is constantly increasing both here and in Europe. To meet the demand for the highest-grade oil in the United States large tracts of land in the vicinity of Gainesville, Fla., have been cleared and thousands of young trees (*A. fordii*) have been planted. Many of these trees were raised from seeds produced at the Florida experiment station. In 1905 the Department of Agriculture imported and distributed seeds from which small plantings were made in Florida, Georgia, and California. Some of these trees are still living.

The fruits from which China-wood oil is obtained somewhat resemble large hickory nuts (entire with husks). Each fruit contains three or more seeds. The oil content of the decorticated seeds ranges from 33 to 50 per cent. In China it is customary to gather this fruit just before it is fully mature.

Preparation

The fruits are either heated in large iron pans over a fire until the husks open, or they are collected in heaps and allowed to ferment under a covering of straw or grass until the seeds can be readily separated from the husks.

At the small oil mills the shelled seeds are crushed in a circular trough with a heavy stone roller. The pulverized mass is then partially roasted in shallow pans, after which it is subjected to a steaming process in wooden vats fitted with wicker bottoms. The heated meal is mixed with straw and made into cakes, which are placed in a crude wooden press consisting of a hollow log of strong wood. Pressure is exerted on the cakes by means of wooden wedges, usually driven in by a huge battering ram. The oil runs from the press into a vat below. Next, the oil is heated slightly and filtered through coarse grass cloth to remove particles of meal and dirt. After being strained, it is placed in covered bamboo baskets lined with layers of paper waterproofed with tung oil and transported to warehouses at the seaports. Here it is crudely separated into different grades, the highest being the lightest in color, and tested for purity. When prices are high tung oil is subject to adulteration with other oils, such as tea-seed, sesame, and peanut oils.

In recent years modern expeller mills have been established in China. In America it has been found that by coarsely crushing the seeds and drying them so that the moisture content is reduced to 7 or 8 per cent, it is possible to express the oil with expellers, thus producing a press cake which does not contain more than 5 per cent of oil. When sound nuts or seeds are expressed cold in the expeller, a very pale oil is obtained. Hot pressing yields a somewhat darker product.

Uses

Tung oil has a strong laxative action, which makes it unfit for edible purposes. Being a drying oil, it is used chiefly in making varnishes, enamels, and floor and wall paints. In China it is also employed for waterproofing paper and fabrics. The so-called spar varnishes, which are not discolored when wet, consist largely of tung oil and rosin glyceride (ester gum).

The press cake, being unfit for cattle food, is used as a fertilizer or for fuel.

CANDLENUT OR LUMBANG OIL

Candlenut oil is obtained from the kernels of the nuts of a large tree (*Aleurites moluccana*) growing in the Philippines, Polynesia, the Malayan region, the Hawaiian Islands, and other tropical countries. These kernels contain from 50 to more than 60 per cent of oil. The Hawaiians formerly strung the nuts on slender bamboos and used them for lighting their huts. This gave rise to the name "candlenut." Some candlenut oil is imported from the Philippines into the United States.

The nuts have very hard shells which are difficult to crack. It is difficult also to separate the kernels from the shells. The procedure which yields the better grades of oil is to crack the dried nuts by hand and pick out the kernels with a pointed instrument, a slow and tedious operation. The kernels are crushed and pressed hot, for the most part in primitive mills. Cold pressing yields a much lighter-colored oil.

In some localities large quantities of the nuts are collected in shallow pits and covered with straw, which is set on fire. The hot nuts are sprinkled with cold water, thus causing the shells to crack. In other places the nuts are boiled for several hours with water, which effects the separation of the kernels from the shells, and then cracked by hand. During this treatment the color of the kernels changes from white to brown, so that only a dark oil can be obtained from them.

In the Philippines the oil is used for the manufacture of paint, varnish, and soap. Candlenut oil, unlike tung oil, does not solidify when heated to 482° F. Extensive experiments in the Philippines have indicated that the oil can be used for any purpose for which linseed oil is now employed. As the press cake is poisonous, its only use is as a fertilizer.

PERILLA OIL

Perilla oil is obtained from the seeds of plants of several species, including *Perilla nankinensis* and *ocymoides* L., which grow in China, Japan, Manchuria, and eastern and northern India. The commercial oil seems to be obtained chiefly from *P. ocymoides*, the seeds of which are about as large as mustard seeds and average 35 per cent in oil. It is reported that a yield of 20 bushels of seed per acre is obtained in Japan. The variety *P. nankinensis* appears to have been employed in all the experiments on the culture of perilla conducted in the United States. As perilla seeds have not been produced in commercial quantities in the United States, all the perilla oil used here is imported from the Orient.

Perilla oil resembles linseed oil in odor and taste and has the property of absorbing more iodine than any other vegetable oil. The crude oil generally is dark yellow or greenish. For a long time it was considered to have drying properties inferior to those of linseed oil, because on drying it separated into drops when spread on a surface. With lead and manganese driers the oil dried unevenly in drops and streaks. Further study of the oil has shown several treatments which will make it dry evenly. When heated to about 482° F. for a short time or when blown with air at a temperature of about 257° F. for several hours, the oil no longer dries in droplets. Cobalt driers used with perilla oil in making paint or varnish make them dry quickly without any indication of streaks or unevenness. Furthermore, paints and varnishes made with perilla oil are said to have as much or more endurance than those made with linseed oil. Perilla oil, refined with sulphuric acid or caustic soda, is employed in the manufacture of light-colored varnishes.

The countries which produce perilla oil use it as a food and also for technical purposes, mainly in the manufacture of paints, varnishes, printers' inks, and linoleum. It has been employed for many years in waterproofing paper and in making the cheaper grades of lacquers. In America and Europe it is used only for technical purposes.

HEMPSEED OIL

Hempseed oil is obtained from a plant (*Cannabis sativa*) which is cultivated for fiber and oil and as a drug. The plant is grown for fiber in India, Manchuria, and Europe and, on a comparatively small scale, in the United States. It is grown for the production of oil in China, Japan, Manchuria, and at times in Italy, France, and Russia. Large quantities of hempseed are imported into this country from the Orient for use as birdseed and poultry feed. The domestic seed is used primarily for planting, because the imported seed is not satisfactory for this purpose.

Hempseed contains about 30 per cent of oil, which when expressed or extracted by solvents has a greenish color.

Hempseed oil is employed chiefly as a paint oil, but in some countries it is used as a lamp oil or converted into a dark-green soft soap. Its drying power is not so pronounced as that of linseed oil.

POPPY-SEED OIL

Poppy seed, which contains usually from 45 to 50 per cent of oil, is grown in Europe, Asia Minor, Persia, India, and Egypt. It may be white, gray, blue, or red. The poppy seed imported into the United States is used chiefly for culinary purposes. The importation of poppy-seed oil is very erratic, ranging from a few gallons up to more than 18,000 gallons per year.

The pale cold-pressed oil, known on the market as white poppy-seed oil, has good keeping qualities. That expressed hot, commonly after the cold expression of the seed, is known as red poppy-seed oil. The white oil is used chiefly for edible purposes, although some is employed in the preparation of artists' paints. The lower grades are used for soap making. In most countries the press or oil cake is used as a cattle food; in India it is used as food for the poorer classes.

ANIMAL FATS AND OILS

The composition of any animal fat or oil is influenced by the inherent variations of animal fats and also by the food eaten by the animal, so that they vary more widely in composition than do the vegetable oils. Like the nondrying vegetable oils, most land-animal fats do not easily absorb oxygen, but, like the drying vegetable oils, most marine-animal oils readily absorb oxygen.

MILK FAT

Milk fat is the most universally and extensively produced fat. In the United States the yearly production of this fat, in the form of butter, cheese, ice cream, and butter substitutes, amounts to about 3,000,000,000 pounds.

Butter is an emulsion of milk fat and water containing small quantities of casein, milk sugar, and inorganic salts. The legal requirement is that it shall contain at least 80 per cent of milk fat.

The butter substitutes now on the American market are of two classes—true oleomargarine, which contains oleo oil and neutral lard, and vegetable or nut margarines, which contain no animal fats other than that in the ripened milk used. Margarines of both types show a wide variation in composition. Not only are the formulas the secret of each manufacturer, but the ingredients in a given brand may vary with the season and with the fluctuations in the market price of the fats and oils used. All are made according to the same general procedure.

LARD

In making kettle-rendered lard the leaf fat is pulled from the warm carcasses of hogs and immediately chilled. When thoroughly cooled, the fat is hashed and heated in steam-jacketed kettles until the oil separates from the tissues. It is then salted and allowed to stand in a melted condition until the fine particles of membrane settle. After the lard has been freed from all particles, it is packed in shipping packages and placed in cold storage. The cracklings, or residue left after rendering, are either pressed to obtain the residual lard or placed in the steam lard tanks. This rendering of lard in steam-jacketed kettles is merely a modification adapted to plant production of the old home procedure of making lard by cooking the hog fat in a large pan or kettle over an open fire or on a stove.

Neutral lard, or neutral, as the packers call it, is made by cooking the first grade of leaf fat in much the same manner as the kettle-rendered lard, but at a lower temperature (126° to 128° F.), so that it retains practically no hog flavor. It is used in the manufacture of oleomargarine.

Steam lard is rendered by live steam. The chopped fat is charged into steel tanks. After the covers have been fastened down, live steam is admitted through the bottoms of the tanks until the lard has separated from the tissues or fat membranes. The water and solids are then allowed to settle, after which the lard is drawn off from the water and solid residue. As some darkening of the lard occurs during the cooking and its flavor is frequently strong, it is customary to bleach and deodorize it in a manner similar to the treatment of cottonseed oil (p. 7).

Lard oil is made by chilling melted lard until the stearin has separated. The stearin, which is removed from the liquid portion or olein by pressing, is often added to whole lard to make it firmer in summer and some is also employed in making lard compound. The olein constitutes the lard oil, which is used in signal lights and miners' lamps and also as a lubricant.

BEEF TALLOW

The handling and rendering of beef fat in the packing house are similar to those employed in making lard. A larger proportion of lard than of tallow is made in open kettles, however. Practically the entire output of tallow from the smaller packing houses is either sold as such or is mixed with cottonseed or other vegetable oil to make "compound," a product used for shortening.

The larger meat packers separate the edible tallow into oleo oil and stearin by the graining process. This consists in placing the melted tallow in truck tanks, which are then wheeled into the graining room, where they remain at the crystallizing temperature of the stearin for a day or longer. Then the semisolid mass is pressed in hydraulic or lever presses, kept at the same temperature as the tallow being grained. The solid cakes of stearin are removed from the presses, melted, and stored in barrels until used for making lard substitutes. The barreled oleo oil is either exported or made into oleomargarine.

Tallow of the inedible grades is used in making candles, soap, leather dressings, and lubricating greases.

MUTTON TALLOW

Mutton tallow is obtained by rendering the fat of sheep and lambs. It closely resembles beef tallow, except that as a rule it is somewhat harder. When melted with beef tallow, it is sold as "mixed tallow." Because of its pronounced flavor and odor it is not employed in the manufacture of oleomargarine or even in high-class toilet soap. Also it has a greater tendency to become rancid than beef tallow.

WHALE OIL

Whale oil is obtained chiefly from the blubber of the whales of the genus Balæna, which includes the right or Greenland whale.

Formerly the blubber was tried on board the whaling vessels by being heated in kettles placed over a fire. The oil thus produced was frequently of low quality, and much was lost because the fatty tissue residues were not pressed. Whenever possible, the whaling ships now bring the catch to trying stations on the coasts.

In the most modern plants the blubber is stripped clean from the flesh as soon as the whale is delivered. The blubber is minced and rendered in the same manner as tallow and other animal fats, except that the process is frequently conducted in several stages, using a higher temperature at each successive step. The oil obtained at the lower temperatures is of the better grade. Finally the flesh and the bones are heated in pressure digesters to obtain the low-grade oil. The quality of the oil varies not only with the methods of extraction but also with the condition of the whale.

Norwegian whalers have recently made another advance in the industry by sending out mother ships with the whaling fleets. The mother ships are floating trying stations, furnished with modern equipment adequate to handle the whale while it is still fresh. The oil thus obtained is of fine quality.

In Norway large quantities of this oil, when hydrogenated, are used to make margarine. In the United States a great deal is employed in making various kinds of soap, including a textile soap. Formerly the oil was so poor in quality and so inefficiently refined that it could not be used in making the better grades of soap. Now that the oil can be refined, bleached, deodorized, and hydrogenated, however, it is used successfully in making a white odorless soap. In some countries it is still used as a burning oil, as a batching oil for jute, and for tempering steel.

PORPOISE OILS

There are two porpoise oils—one obtained from the head and the other from the blubber of the porpoise. A quantity of head oil is prepared in America for lubricating watches, clocks, and other delicate instruments. The blubber yields an oil which is inferior to head oil for lubricating purposes, but which after suitable treatment may be used as a lubricant.

BONE FAT

Bone fat is a by-product in the manufacture of animal charcoal and the production of glue and gelatin. The degreasing of the bones is the first step in these processes. The fat is either separated from the bones by heating with steam, preferably under pressure, or by solvent extraction, in which case a larger yield of fat is obtained. When fresh bones are used the recovered fat has a white to a light-yellow color and a faint odor and taste. It is sold as butter-stock tallow.

Bone fat is grained, in the same manner as tallow, for the preparation of bone oil. This is used as a lubricant and for other purposes for which neat's-foot oil is employed. Bone fat of suitable quality is also used in soap making.

NEAT'S-FOOT OIL

Most of the neat's-foot oil produced is a by-product from the large beef-packing establishments.

The feet from the slaughtered animals are cleaned and left in hot water for 10 or 15 minutes. The hoofs are separated by a special machine called the hoof puller, and the feet are then boiled with water. The oil which rises to the surface is removed by skimmers, filtered, and separated as completely as possible from the water. The residual moisture is removed by heating the oil in a tank provided with steam coils. This treatment causes the coagulation and precipitation of organic matter, which is removed by filtration. The finished oil is pale yellow and has a bland taste.

Oil of the better grades is used for lubricating clocks and other delicate machinery. Neat's-foot oil is used extensively in the leather industry as "fat liquoring" in the production of the lightweight grades of leather.

Neat's-foot oil is frequently adulterated with oil from the feet of other animals and also with other oils.

FISH OILS

Menhaden oil is obtained from menhaden caught off the Atlantic coast of the United States from about May until November. The fish are delivered by automatic conveyors in a comparatively fresh condition from the steamers to the plant, where they are weighed, transferred to tanks, and cooked with steam. After cooking the fish scrap is allowed to settle and the oil to rise. The oil is separated from the water and clarified. The scrap is removed from the settling tank, pressed to further extract the oil, and dried. This oil is of a lower grade than that first obtained and is kept by itself. Oil from fresh fish is light colored. The longer the fish are kept before extracting the oil the darker the oil will be. The better grades of oil are wintered (p. 7) to separate the stearin, and some is bleached with fuller's earth to produce what is known in the trade as bleached winter white oil. Menhaden oil is used for currying leather, in the preparation of chamois skins, for tempering steel, for making soap, and for manufacturing paints, printing inks, and insecticide emulsions. Sulphonated menhaden and other fish oils are employed chiefly by the textile and leather industries. The dried scrap is sold as a feed or as a fertilizer.

Salmon oil, a by-product from the north Pacific canning industry, is exported in large quantities from British Columbia to England. The entire fish contains about 20 per cent of oil. The oil is obtained from the parts of the fish not suitable for canning. Like other fish oils, it is used principally by the soap and leather industries.

Herring oil, made in Great Britain, Japan, and Norway, has poor drying properties. It is used largely by the leather industry.

FISH-LIVER OILS

For centuries cod-liver oil has been prepared from cod livers on the coasts of Japan and the Scandinavian Peninsula. A great deal is now made in Newfoundland.

By the old method the livers, collected in barrels or vats, were allowed to rot while they were exposed to the air until the oil floated to the top. It could then be removed. Another process, which was used later, consisted in trying out the oil in pans over open fires. The oil made by either process was very unpalatable. About 1850 the steaming method had come into use in Newfoundland and Norway. The oil first separated from fresh livers by modern equipment in clean establishments is of fine quality, both in color and flavor. This oil varies from a very light to a golden-yellow color.

The electrolytic process recently developed for extracting cod-liver and other oils consists in passing the minced fresh livers, suspended in brine heated to about 155° F., through a series of cells, composed of pipes containing carbon rods. The electric current, passing between the carbon electrodes and the pipes, through the brine solution containing the livers, breaks the oil cells and liberates the oil. The oil is separated from the brine and solids by centrifuges. Three minutes after the livers have entered the cells the oil is obtained from the separators.

For the production of medicinal cod-liver oil, the crude oil is clarified by filtration and sometimes bleached. It is then put through a wintering process (p. 7) to separate the stearin.

The general use of cod-liver oil in the treatment of malnutrition and associated diseases is comparatively recent, although cod livers and the oil from them have been used for centuries as a medicine.

At one time the low-grade, dark oil was believed to be more valuable than the light-colored oil obtained from fresh livers. The light-colored oil is now considered better.

Low-quality cod-liver oils are employed chiefly by the leather industry.

The oil extracted from the livers of various species of dogfish, sharks, and rays is used chiefly for technical purposes. The extraction of shark-liver oil, practiced for a long time in the Orient, particularly on the coasts of Japan, has recently become an established industry at several places on the Atlantic seaboard of the United States.

WAXES

BEESWAX

The worker bees secret beeswax, which constitutes the honeycomb. The color of the crude beeswax ranges from light yellow to orange red.

Most of the methods for rendering the wax are based on melting it and either allowing the impurities to settle or removing them by filtration. Large producers grade the combs before they render the wax, separating those of better quality from the older and discolored combs. The modern commercial method consists of melting the comb freed from honey, removing the larger impurities, and pressing the molten wax in a warm press. The residue is heated and pressed once or twice more in order to obtain as much of the wax as possible. Small producers boil the wax with water and allow the mixture to stand until the impurities have settled and the wax has risen to the surface. The wax may be skimmed off at once or allowed to solidify, in which state it can be more completely removed. When necessary the treatment with boiling water is repeated once or several times to further purify the wax. The wax obtained by any of these methods constitutes the yellow beeswax of commerce.

Crude beeswax varies in character and composition with the race of the bees, the variety of pollen which they consume, and the care used in preparation. The lighter-colored waxes, which may be readily bleached, are more valuable than darker-colored waxes. Crude beeswax of good quality has a sweet characteristic odor, is brittle when cold, and exhibits on fracture a coarse granular structure. Bleached wax is more brittle than the unbleached and shows a smooth, nongranular fracture.

Beeswax is bleached either by exposing it in the form of thin ribbons to moisture and sunlight or by treating it with ozone, hydrogen peroxide, or other chemical bleaching agent. The satisfactory chemical bleaching of the wax requires suitable equipment and much experience. Beeswax from some sources can never be more than partially bleached. Bleached wax of good quality is either white or very light yellow.

Beeswax is used chiefly in making polishes, modeling wax, and candles. Smaller quantities are used in pharmaceutical preparations, for treating leathers, and for waterproofing.

CARNAUBA WAX

Carnauba wax is exuded by the leaves of the carnauba palm (*Copernicia cerifera*), which grows in the hot dry sections of northeastern Brazil. Brazil produces about 5,000 tons of the wax a year.

The leaves are dried by exposure to the sun for several days. Then the wax is brushed and scraped from them. About 70 leaves yield a pound of wax. The separated wax is placed in boiling water, and in a short time it collects at the surface in the form of a doughlike mass, which, after cooling, is removed. The crude wax is refined by remelting in water. Some of it is bleached by treatment with fuller's earth or other bleaching agent. To facilitate bleaching, it is customary to mix the wax with 2 to 5 per cent of paraffin wax. Consequently the finished product melts at a somewhat lower temperature than the unbleached wax.

Carnauba wax is graded according to its quality and color, the chalky wax being the lowest and cheapest grade. It is used in making candles, polishes, and phonograph records, and for waterproofing.

CANDELILLA WAX

Candelilla wax is obtained from a plant belonging to the Euphorbiaceæ family and growing in the semiarid regions of northern Mexico and southern Texas. The plant consists of a bundle of slender, leafless stalks, 2 to 4 feet high, which are coated with a grayish-green wax. It contains from 2 to 5 per cent of wax.

Several boiling or steaming methods and one based on the extraction of this wax with volatile solvents have been patented. The customary procedure for obtaining the wax is to boil the dried plants, one or two weeks after they have been gathered, for 5 or 10 minutes with water acidified with sulphuric acid, which facilitates the separation of the wax from the stalks. The wax, which rises to the surface, is removed by skimming. Sometimes the skimmed wax is placed in steam-heated vats until most of the water is removed. The wax is then drawn into large pans and allowed to harden. The dirt and plant débris, which settle to the bottom of the cakes of wax, are cut off and returned to a small refining vat for the recovery of more wax. The yield of wax by this method ranges from 1.5 to 2.5 per cent.

Candelilla wax, which is hard and light brown in color, is used in making polishes, leather dressings, and candles and as an insulating material.

MONTAN WAX

Montan wax, produced chiefly in Saxony and Bohemia, is obtained by extracting dried lignite by volatile solvents under pressure. The crude wax varies in color, but the refined wax is pale yellow. The wax is hard and brittle and breaks with a conchoidal fracture. Its melting point varies from 168.8° F. to about 194° F. The wax is used in manufacturing shoe and other polishes, cable insulations, and phonograph records, and for treating leather.

Chlorinated montan wax made by a patented process is employed for insulation purposes and as a substitute for beeswax in Great Britain.

SUGAR-CANE WAX

Sugar-cane wax, which is on the outside of the sugar canes, is a by-product from the manufacture of sugar. Java and Natal are the principal producers. Sometimes this wax is imported into the United States, but the bulk of the production is used in Europe.

By one of the several methods of preparation which have been patented the canes are propelled through a tank of hot water and the wax which rises to the surface of the water is made to float over the top of the tank into a vat, where it is recovered. By another process the wax is extracted from the filter-press residues obtained from liming the juice. The crude wax is usually dark brown or dark green and is very difficult to bleach.

Sugar-cane wax is used in making polishes and for insulation. For some purposes it can be used in place of carnauba and montan waxes.

WOOL WAX (GREASE)

Wool grease is composed of wax, cholesterol, free fatty acids, and the potassium salts of fatty acids (soaps).

During the preparation of raw wool for spinning the grease and dirt are removed, usually by washing with solutions of soap and sodium carbonate, although in some plants extraction by volatile solvents is employed. When the extraction method is used, it is important not to extract all of the grease. Complete extraction causes injury to the fiber by the solvent. In the washing process it is now common to pass the wash water through specially designed centrifugals to separate the wax, using the soapy water for further washing. This practice saves soap by increasing the quantity of potassium soaps obtained from the repeated treatment of fresh lots of raw wool. Sometimes these wash waters are utilized for the production of potassium carbonate and other potassium salts. The crude wool wax is purified either by repeated treatment with hot water or by pressing in a hydraulic press after any adhering soluble soap has been removed. The refined product is on the market in two forms, the hydrated form being known as lanolin.

Owing to its property of forming an emulsion with water and to the ease with which it is absorbed by the skin, the refined wax is used as a basis for ointments, salves, and cosmetics. The crude product, known in commerce as wool grease, is used in stuffing leather, in cordage manufacture, and in the preparation of lithograph inks.

SPERM OIL (WAX)

Sperm oil is obtained from the head cavities and blubber of the sperm whale or cachalot. After being received at the refinery the oil is subjected to a graining process (p. 28). Crude sperm oil yields 10 to 11 per cent of spermaceti. The liquid portion or oil is used for lubrication purposes. The solid residue is crude spermaceti, which, after being refined, is used chiefly in making candles and cosmetics.

Sperm oil is a liquid wax and the commercial product contains only very small quantities of glycerides. The oil from the smaller bottlenose whale, known as Arctic sperm oil, is similar to that from the sperm whale. On account of its more pronounced tendency to

gum when used for lubrication purposes, however, it brings a lower price.

PRODUCTION AND CONSUMPTION STATISTICS

Table 1 shows the quantities of fats and oils produced and consumed in the United States from 1921 to 1925, inclusive. Table 2 shows the quantities of oil-producing seeds imported into the United States during the same period, and Table 3 shows the quantities of raw materials used in the production of oils in this country from 1921 to 1925, inclusive. All the figures given are taken from the reports issued by the Bureau of the Census of the United States Department of Commerce.

TABLE 1.—*Production, consumption, and importation of fats and oils in the United States, 1921–1925*

Product	Production				
	1925	1924	1923	1922	1921
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Cottonseed oil:					
Crude	1,510,802,294	1,154,433,880	973,753,164	934,627,442	1,277,300,130
Refined	1,345,461,442	1,056,673,231	857,979,352	827,204,553	1,185,909,960
Peanut oil:					
Crude	15,156,315	6,691,244	5,358,647	22,644,253	33,233,378
Refined	8,331,570	6,109,531	5,950,409	23,472,252	34,200,050
Coconut oil:					
Crude	207,604,172	191,357,413	235,918,724	185,526,073	113,194,282
Refined	197,118,259	173,719,921	172,381,589	135,242,528	122,675,416
Corn oil:					
Crude	104,153,269	117,064,953	111,343,267	111,508,447	87,480,934
Refined	79,624,310	93,921,515	82,887,570	85,569,288	61,426,528
Soy-bean oil:					
Crude	2,519,938	950,437	1,404,035	751,108	----------
Refined	----------	1,797,085	2,567,769	3,217,796	5,656,166
Olive oil:					
Edible	513,610	1,509,412	573,867	584,883	974,425
Foots or sulphur oil	----------	----------	----------	----------	----------
Palm-kernel oil:					
Crude	----------	----------	----------	----------	1,327,382
Refined	1,031,569	632,216	689,751	800,294	978,965
Rapeseed oil	----------	30,000	----------	58,125	127,905
Linseed oil	763,822,379	705,585,985	653,563,870	456,514,418	482,917,742
China-wood or tung oil	----------	----------	----------	----------	----------
Castor oil	45,049,646	37,433,650	37,382,715	31,486,885	20,595,268
Palm oil	----------	----------	----------	----------	----------
Chinese vegetable tallow	----------	----------	----------	----------	----------
Fish oils:					
Cod-liver	1,070,790	798,112	707,955	536,542	373,920
Menhaden	46,618,856	29,429,280	55,960,238	53,270,078	49,953,565
Whale	8,071,110	8,562,712	10,097,670	13,972,612	2,657,790
Herring (including sardine)	41,741,242	27,470,347	14,337,532	6,594,152	2,128,612
Sperm	1,090,099	758,557	1,578,555	2,880,975	1,265,468
All other (including marine animal)	2,571,408	2,065,702	2,621,558	1,761,722	2,285,325
Animal fats:					
Lard—					
Neutral	46,628,612	68,323,719	60,960,546	49,431,962	63,110,364
Other edible	1,506,892,385	1,934,545,302	1,944,862,331	1,575,639,547	1,454,854,775
Tallow—					
Edible	50,215,381	51,675,829	52,923,030	49,108,268	41,237,809
Inedible	378,471,536	388,295,393	384,045,626	362,817,541	326,905,156
Neat's-foot oil	9,247,315	8,505,673	8,397,530	8,806,999	6,953,795
Greases (partial)—					
Wool grease	4,474,673	4,333,878	7,313,876	4,114,600	6,076,080
White	73,097,022	93,630,359	97,500,001	82,305,027	65,526,980
Yellow	64,457,211	71,200,443	67,356,983	56,929,003	45,914,431
Brown	40,589,623	43,776,688	56,253,331	43,373,507	33,685,444
Bone	24,476,482	26,761,712	27,992,177	27,324,784	26,775,547

TABLE 1.—*Production, consumption, and importation of fats and oils in the United States, 1921–1925*—Continued

Product	Consumption				
	1925	1924	1923	1922	1921
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Cottonseed oil:					
Crude	1,475,322,331	1,163,820,744	934,994,608	895,161,564	1,295,740,304
Refined	1,161,115,204	779,858,005	675,245,550	734,068,771	895,032,630
Peanut oil:					
Crude	10,323,544	8,650,913	7,504,233	28,372,261	42,542,807
Refined	8,800,662	5,683,564	7,548,428	28,907,302	34,686,139
Coconut oil:					
Crude	385,454,710	363,770,156	360,002,327	305,330,218	235,090,359
Refined	205,776,941	210,900,864	211,940,058	165,080,442	139,417,771
Corn oil:					
Crude	102,189,998	114,161,763	103,068,067	106,097,173	71,898,447
Refined	10,403,096	13,987,412	18,596,367	28,287,639	7,766,123
Soy-bean oil:					
Crude	11,328,771	10,749,346	19,341,400	17,570,440	28,822,307
Refined	5,501,481	5,882,260	6,762,002	4,601,115	10,526,957
Olive oil:					
Edible	2,345,817	2,862,295	2,157,778	3,678,416	2,515,468
Foots or sulphur oil	28,963,212	22,197,514	24,831,718	22,190,152	11,546,001
Palm-kernel oil:					
Crude	50,990,646	5,361,849	4,529,899	1,922,941	2,657,821
Refined	4,416,658	206,198	398,354	194,372	1,838,730
Rapeseed oil	11,478,552	12,200,129	11,439,298	10,159,389	7,445,428
Linseed oil	413,942,837	381,407,503	381,245,301	344,362,688	242,721,325
China-wood or tung oil	87,881,315	70,529,915	72,333,664	62,855,998	35,965,800
Castor oil	16,304,612	14,813,229	16,733,979	12,075,138	6,442,055
Palm oil	109,824,921	78,656,193	114,385,473	43,961,819	22,826,725
Chinese vegetable tallow	8,328,592	6,630,522	5,562,327	4,086,666	2,876,501
Fish oils:					
Cod-liver	12,281,149	11,585,447	11,736,936	15,273,866	8,347,417
Menhaden	48,473,310	34,288,576	55,373,236	36,135,978	60,693,254
Whale	52,661,795	40,454,865	38,302,824	51,141,796	5,621,410
Herring (including sardine)	31,859,086	26,228,036	11,098,945	4,775,585	951,887
Sperm	1,573,918	1,128,341	1,150,223	1,467,247	1,820,025
All other (including marine animal)	7,474,665	2,581,104	1,038,235	1,257,627	2,526,783
Animal fats:					
Lard—					
Neutral	26,096,239	29,770,088	31,230,340	29,344,859	29,490,281
Other edible	14,548,792	21,226,673	25,353,148	28,837,168	110,037,581
Tallow:					
Edible	38,850,912	33,684,686	34,765,963	26,418,921	23,587,483
Inedible	478,960,645	516,440,781	465,868,998	463,925,337	398,670,773
Neat's-foot oil	5,877,586	6,321,808	6,743,461	7,644,788	3,509,222
Greases (partial)—					
Wool grease	4,254,402	4,603,045	3,630,245	2,753,121	1,544,301
White	24,858,880	45,217,261	59,727,341	51,469,261	38,947,944
Yellow	78,401,045	60,040,415	57,083,050	56,380,038	36,423,957
Brown	27,345,821	29,029,523	39,683,343	36,254,652	31,820,237
Bone	748,466	1,880,772	1,773,618	3,273,242	3,214,920

Product	Imports				
	1925	1924	1923	1922	1921
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Cottonseed oil (crude)			25,044	20,779	668,551
Peanut oil (crude)	3,026,950	15,394,836	8,008,622	2,469,938	3,020,505
Coconut oil (crude)	233,174,452	222,793,441	181,882,149	227,320,096	189,716,814
Soy-bean oil (crude)	19,492,900	9,125,158	41,679,110	17,325,496	17,282,967
Olive oil:					
Edible	90,426,346	76,186,446	77,190,457	61,186,645	49,710,742
Foots or sulphur oil	40,822,557	24,678,006	40,604,535	26,787,795	19,028,222
Palm-kernel oil (crude)	52,624,334	4,747,597		1,714,880	2,383,483
Rapeseed oil	12,735,195	17,362,080	15,932,475	10,860,765	7,151,917
Linseed oil	13,607,141	13,247,190	43,096,714	144,136,792	60,090,712
China-wood or tung oil	101,553,519	81,587,854	87,291,675	79,089,292	27,248,888
Palm oil	139,178,587	101,779,802	128,494,679	57,516,079	23,155,230
Chinese vegetable tallow	6,423,896	5,196,904	8,547,617		
Fish oils:					
Cod-liver	22,316,678	21,349,410	17,374,237	13,571,085	16,567,732
Whale	55,495,290	38,057,032	29,812,523		
Herring (including sardine)	6,194,962	5,635,305	5,375,625		
Animal fats:					
Tallow (inedible)	2,723,804	3,417,936	11,373,792	1,831,527	1,868,412
Wool grease	10,068,425	12,576,853			

TABLE 2.—*Oil-producing seeds imported into the United States, 1921–1925*[1]

Product	Quantity imported				
	1925	1924	1923	1922	1921
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Castor beans	107, 231, 669	84, 977, 470	88, 539, 306	81, 673, 345	33, 639, 800
Copra	364, 079, 144	291, 064, 369	332, 984, 498	268, 956, 000	189, 320, 000
Cottonseed	63, 831, 982	95, 052, 650	68, 761, 608	68, 762, 000	82, 598, 000
Flaxseed	924, 542, 416	928, 980, 640	1, 362, 608, 128	835, 138, 000	690, 269, 664
Hempseed	4, 018, 144	4, 523, 195	2, 558, 245	4, 180, 000	1, 142, 000
Palm nuts and kernels	56, 856	16, 529	742, 401	188, 000	230, 000
Perilla and sesame	3, 900, 958	13, 865, 986	13, 650, 480	366, 000	242, 000
Poppy seed	3, 914, 660	4, 968, 263	6, 291, 437	5, 256, 000	4, 828, 000
Rape seed	7, 457, 645	4, 843, 236	8, 385, 007	6, 336, 000	5, 114, 000
Soy beans	3, 811, 897	4, 184, 120	3, 648, 243	3, 536, 000	3, 946, 000
Sunflower seed	430, 591	1, 089, 092	5, 677, 525	12, 000	None.
Other oil seeds	160, 177	278, 987	247, 131	4, 614, 000	13, 554, 000

[1] These seeds were not used exclusively for oil production.

TABLE 3.—*Raw materials used in production of oils in the United States, 1921–1925*

Product	Quantity used				
	1925	1924	1923	1922	1921
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Cottonseed	10, 159, 512, 000	7, 717, 584, 000	6, 403, 446, 000	6, 085, 866, 000	8, 060, 298, 000
Peanuts:					
Shelled	39, 062, 000	17, 998, 000	10, 000, 000	20, 648, 000	21, 990, 000
In shell	9, 208, 000	2, 746, 000	9, 622, 000	57, 016, 000	91, 718, 000
Copra	321, 412, 000	296, 530, 000	369, 962, 000	287, 044, 000	172, 200, 000
Coconuts and skins	5, 206, 000	4, 088, 000	4, 632, 000	5, 232, 000	5, 758, 000
Corn germs	392, 256, 000	425, 668, 000	321, 144, 000	306, 306, 000	246, 640, 000
Castor beans	99, 842, 000	84, 948, 000	88, 820, 000	72, 140, 000	46, 228, 000
Flaxseed	2, 310, 768, 000	2, 132, 962, 000	1, 913, 736, 000	1, 357, 118, 000	1, 457, 458, 000
Olives	3, 858, 000	11, 568, 000	4, 396, 000	4, 020, 000	6, 582, 000
Mustard seed	3, 592, 000	2, 596, 000	4, 080, 000	3, 600, 000	6, 144, 000
Palm kernels					1, 942, 000
Rape seed					598, 000
Soy beans	20, 338, 000	7, 448, 000	9, 050, 000	5, 956, 000	
Other seeds	1, 360, 000	25, 160, 000	12, 272, 000	9, 816, 000	742, 000

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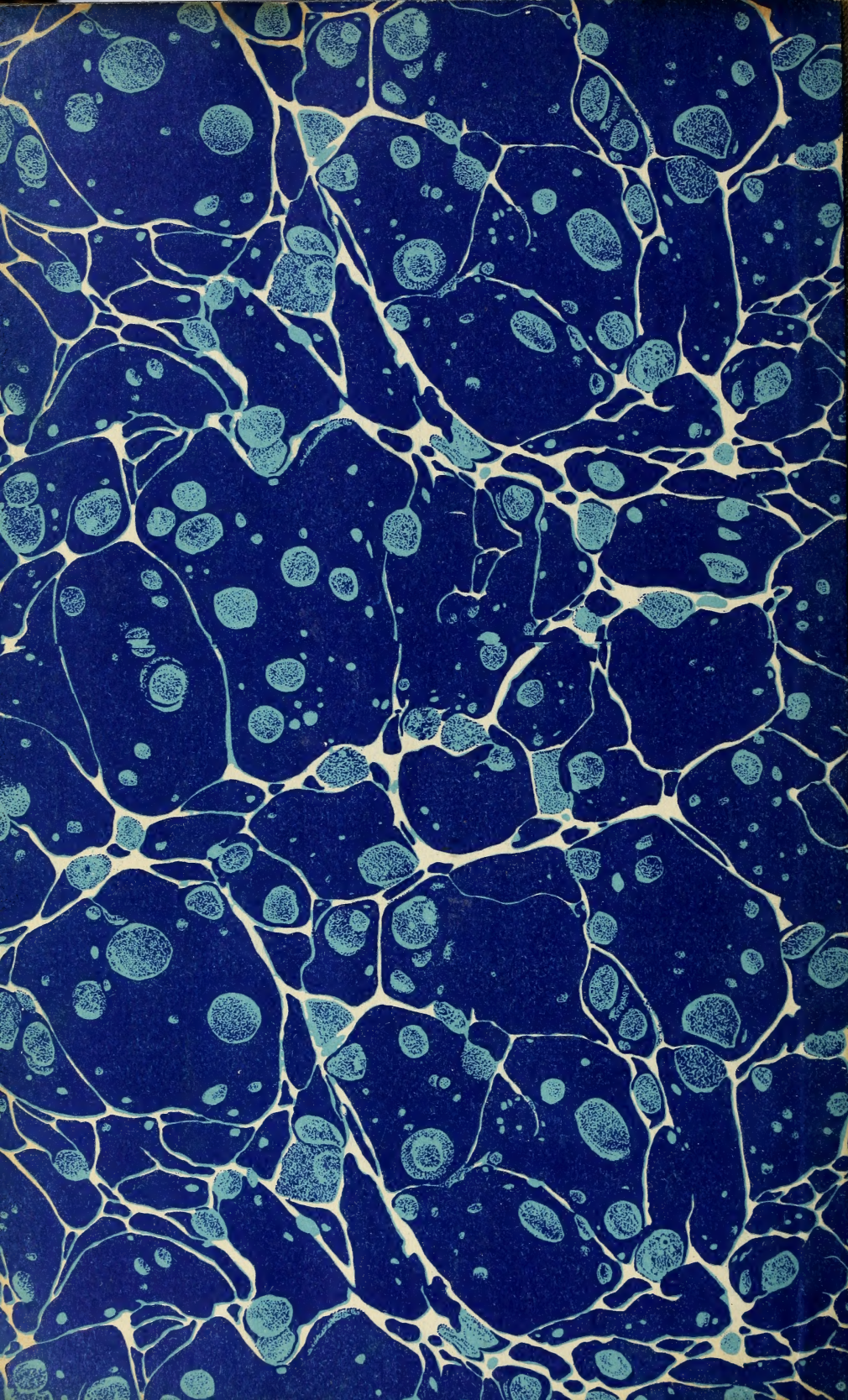

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